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The following paper is to be presented at the AIAA 37th Aerospace Sciences Meeting and Exhibit, January 11-14, 1999, in Reno, Nevada.

1999059766
REPRINT
IN-34
C/NMF/MARSHALL
ABS. ONLY

**Control of Meridional Flow in Circular Cylinders
by a Travelling Axial Magnetic Field**

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Convective flow in a Bridgman or float zone configuration significantly affects the interface shape and segregation phenomena. While the primary causative factor for this flow is buoyancy induced convection in an enclosed Bridgman melt, the presence of a free surface gives rise to surface tension driven flows in the floating zone processing of melts. It is of interest to curtail these flows in order to realize near quiescent growth conditions that have shown to result in crystals with good longitudinal and radial homogeneity and thereby of better overall quality. While buoyancy effects can be reduced by careful processing in a low gravity (space) environment, the reduction of Marangoni flows due to surface tension variations is not that straight forward. Attempts have been made with some limited success with the use of external fields to affect the melt thermo-fluid behavior. The use of a static magnetic field that reduces convective contamination through the effects of a non-intrusively induced, dissipative Lorentz force in an electrically conducting melt is one such approach. Experiments have shown that axial fields of the order of 5 Tesla can significantly eliminate convection and yield close to diffusion limited crystal growth conditions. The generation and use of such high magnetic fields require substantial hardware and incur significant costs for its operation. Lately, the use of rotating magnetic fields has been tested in semiconductor crystal growth. The method is fairly well known and commonly used in metal processing but its adaptation to crystal growth of semiconductors is fairly recent. The elegance of the technique rests in its low power requirement (typically 10-20 milliTesla at 50-400 Hz) and its efficacy in curtailing deleterious temperature fluctuations in the melt. A rotating magnetic field imposes a rotational force and thereby induces a circulation within the melt that tends to dominate other sporadic convective effects. Thus a known low level of convective flow is introduced into the system. A new novel variation of the Lorentz force mechanism is proposed and investigated in this study.

Since one of the desired process conditions in melt crystal growth is the minimization of convective effects, this investigation examines the use of an external field of magnetic origin to counteract existing convective flow within the melt. This is accomplished by utilizing a running or traveling axial magnetic wave in the system. The concept is similar to the use of vibrational means in order to induce streaming flows that oppose buoyant or surface tension driven convection in the system. The rotation direction as well as the magnitude (strength) of this circulation can be easily controlled by external inputs thus affording a direct means of controlling the developing shape of the crystallizing front (interface). The theoretical model of this technique is fully developed and presented in this paper. Results from the solution of the developed governing equations and boundary conditions are also presented. An experimental demonstration of the concept is presented through the suppression of natural convective flow in a mercury column. Implications to crystal growth systems will be fully explored in the final manuscript.